"DOSE COMPARISON OF HYPERBARIC BUPIVACAINE FOR SPINAL ANAESTHESIA IN CHILDREN UNDERGOING INFRA-UMBILICAL SURGERIES"

Submitted to

THE TAMILNADU DR. M.G.R. MEDICAL UNIVERSITY

In partial fulfilment of the requirements

for the award of degree of

MD (BRANCH - X)

ANAESTHESIOLOGY

GOVERNMENT STANLEY MEDICAL

COLLEGE & HOSPITAL

THE TAMILNADU Dr. M.G.R. MEDICAL UNIVERSITY

CHENNAI, TAMILNADU

MARCH – 2010

CERTIFICATE

This is to certify that the dissertation titled "**Dose Comparison Of Hyperbaric Bupivacaine For Spinal Anaesthesia In Children Undergoing Infra-Umbilical Surgeries"** is a bonafide original work done by **Dr.Pavithra Ramamurthi** in partial fulfilment of the requirements for M.D.(Anaesthesiology) Branch X Examination of the TamilNadu Dr.M.G.R. Medical University to be held in March 2010. The period of the study was from May 2007 to March 2010.

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ACKNOWLEDGEMENT

I wish to express my sincere gratitude to **Dr.A.Priya, M.S., D.O.,** Dean, Government Stanley Medical College and Hospital for having kindly permitted me to utilize the facilities of the hospital for the conduct of the study.

My heartfelt gratitude to **Prof.Dr.R.Subramaniya Bharathiyar, MD., DA., Professor & HOD**, Department of Anaesthesiology, Government Stanley Medical College and Hospital for his motivation, constant supervision and for all necessary arrangements for the conduct of the study.

I am greatly indebted to **Prof.Dr.P.Chandrasekar, MD., DA.** whose encouragement and supportive presence throughout the period of the study helped me through my study.

I am grateful to **Prof.Dr.R.Madhan Kumar, MD., DA.** who was instrumental in helping me get the approval of the institutional Ethical Committee and his valuable suggestions.

I sincerely thank **Prof.Dr.R.Lakshmi, MD., DA.** and **Prof.Dr.Ponnambala Namasivayam, MD., DA.**, who guided me throughout the study and offered constructive criticism and suggestions throughout the period of the study.

I am deeply indebted to **Prof.Dr.B.Kala, MD., DA.** and **Prof.Dr.S.Gunasekaran, MD., DA.** for their ideas and immense support during the early periods of my study.

I wish to thank **Prof.Dr.R.Madhavan, Head of Department, Paediatric Surgery**, Government Stanley Medical College for permitting me to conduct the study in the paediatric surgery theatres.

I express heartfelt gratitude to **Dr.S.Saravanakumar, MD., DNB.** who as my guide and mentor, evinced constant and keen interest in the progress of my study right from the inception till the very end and was instrumental in the successful completion of the study.

I wish to thank all Assistant Professors especially **Dr.Deepalakshmi, MD., Dr.Jegan Mohan, DA., Dr.Padmini, MD.** and **Dr.V.Bhavani, MD., DNB**. for their aid and encouragement during the study.

I thank Mr.Padmanaban, Statistician, for helping me with the statistical analysis.

I thank all my colleagues for their valuable support during the study period.

I thank all theatre personnel for their co-operation.

I profoundly thank all patients without whose participation, this study would not have been possible.

Finally, I wish to express my heartfelt gratitude to my parents and The Almighty who saw me through the entire study.

CONTENTS

INTRODUCTION

Spinal anaesthesia is induced by injecting small amounts of local anaesthetic into the cerebro-spinal fluid (CSF). The injection is usually made in the lumbar spine below the level at which the spinal cord ends. Spinal anaesthesia is easy to perform and has the potential to provide excellent operating conditions for surgery below the umbilicus. Advantages include rapid onset, profound sensory and motor block, and lack of systemic effects, avoidance of tracheal intubation and a decreased need for opioid administration. Other theoretical benefits include the attenuation of the neuroendocrine response to surgical stress, facilitation of rapid tracheal extubation (for combined techniques), improved ventilatory mechanics, and decreased post-anaesthesia care unit and hospital stay.

Spinal anaesthesia is an excellent option in paediatric population as it provides a rapid onset of profound and predictable uniformly distributed analgesia with good neuromuscular blockade. Spinal anaesthesia has traditionally been used in ex-premature neonates and infants<60 weeks post-conceptional age who are at an increased risk of post-operative apnoea due to bronchopulmonary dysplasia and

prematurity[1,2]. Spinal anaesthesia has also been used in older children to provide intra- and post-operative analgesia, especially for procedures done as day-case surgery[4]. Paediatric spinal anaesthesia has proven to be a safe alternative to routinely administered general anaesthesia as it avoids the polypharmacy associated with the latter technique and also reduces the incidence of post-operative respiratory complications associated with administration of general anaesthesia[2].

AIM OF THE STUDY

To compare two different doses- 0.3mg/kg and 0.5mg/kg- of 0.5% hyperbaric Bupivacaine given intrathecally in children aged 5-12 years undergoing surgeries of the lower extremities and infra-umbilical procedures; in terms of duration of analgesia and incidence of intra- and post-operative complications.

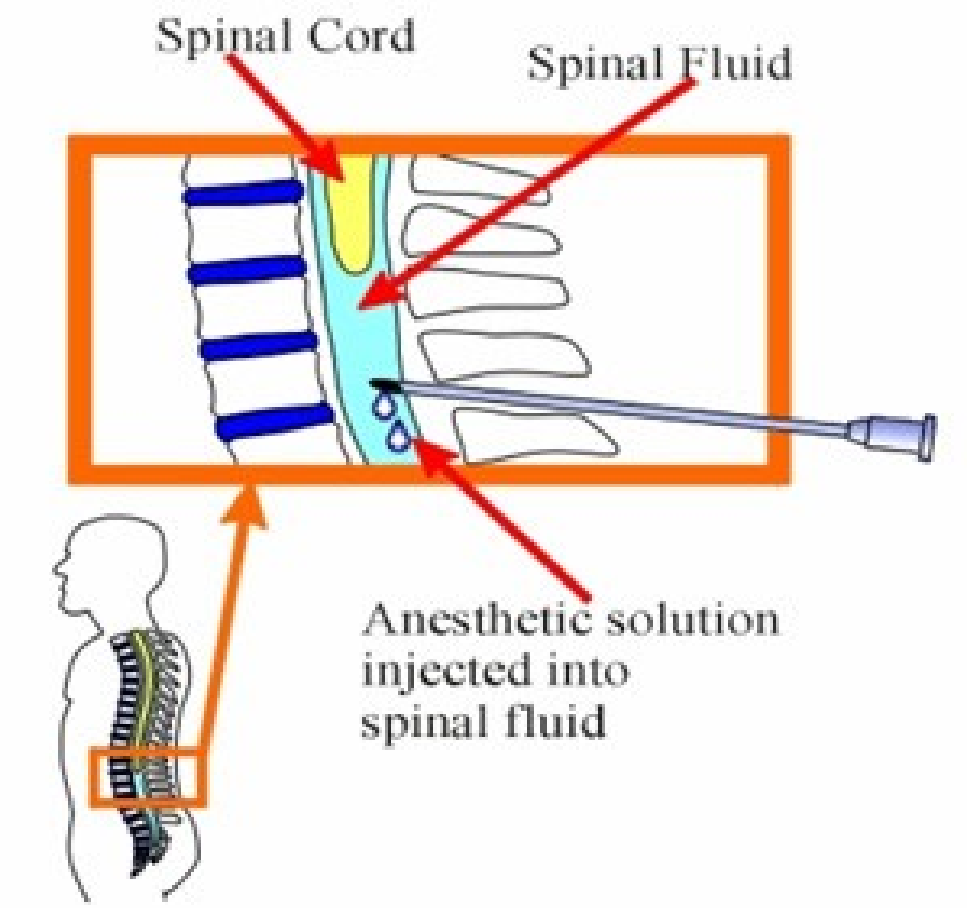
HISTORY OF PAEDIATRIC SPINAL ANAESTHESIA

Regional anaesthesia in children was first studied by August Bier in 1899. In 1900, Bainbridge reported a case of strangulated hernia repair under spinal anaesthesia in an infant aged three months. Thereafter, Tyrell Gray, a British surgeon published a series of 200 cases of lower abdominal surgeries in infants and children under spinal anaesthesia in 1909-1910. After some years it fell into disuse because of the introduction of various muscle relaxants and inhalational agents and was almost unused after World War II. Despite scattered reports, it was not until a 1984 study by Abajian et al[1], that infant spinal anaesthesia was successfully reintroduced to the modern era.

Since that time, infant spinal anaesthesia has been used alone or in combination with epidural anaesthesia for a variety of surgical procedures, including inguinal hernia repair, exploratory laparotomy, repair of gastroschisis, orthopaedic procedures, pyloromyotomy, and meningomyelocele repair and as an adjunct to general anaesthesia in infants undergoing repair of complex congenital heart disease with cardiopulmonary bypass.

ANATOMY

The spinal cord usually ends at the level of L_2 in adults and L_3 in children[9,10,15]. Dural puncture above these levels is associated with a slight risk of damaging the spinal cord and is best avoided. An important landmark to remember is that a line joining the top of the iliac crests is at L_4 to L_5[8,11]. The following structures are pierced as the needle enters the CSF[12].



Skin. It is wise to inject a small bleb of local anaesthetic into the skin before inserting the spinal needle.

Subcutaneous fat. This is of variable thickness. Identifying the intervertebral spaces is far easier in thin patients.

S**upraspinous ligament** joins the tips of the spinous processes together.

The **interspinous ligament** is a thin flat band of ligament running between the spinous processes.

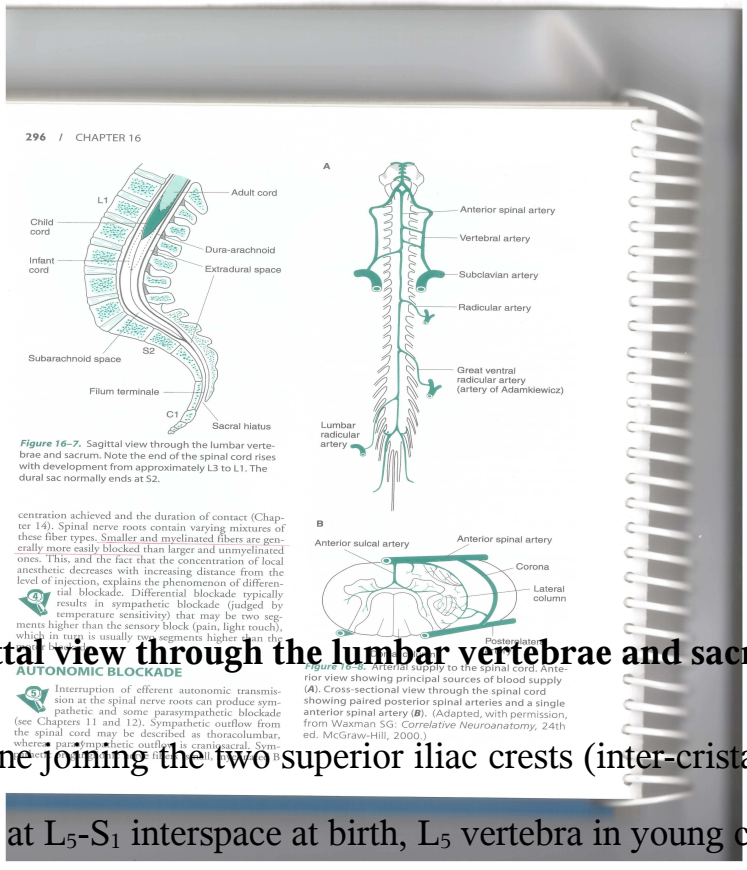
The **ligamentum flavum** is quite thick, up to about 1cm in the middle and is mostly composed of elastic tissue. It runs vertically from lamina to lamina. When the needle is within the ligaments it will feel gripped and a distinct "give" can often be felt as it passes through the ligament and into the epidural space.

The **epidural space** contains fat and blood vessels. If blood comes out of the spinal needle instead of CSF when the stylet is removed, it is likely that an epidural vein has been punctured. The needle should simply be advanced a little further.

The Dura. After feeling a "give" as the needle passes through the ligamentum flavum, a similar sensation may be felt when the needle is advanced a further short distance and pierces the Dural sac.

The **subarachnoid space**. This contains the spinal cord and nerve roots surrounded by CSF. An injection of local anaesthetic will mix with the CSF and rapidly block the nerve roots with which it comes in contact.

Spinal anaesthesia is obtained by blocking the spinal nerves with drug administered into the sub-arachnoid space, below the level of termination of the spinal cord. The spinal cord ends at L_3 level at birth and reaches L_1 by 6-12 months. The Dural sac is at the S_4 level at birth and reaches S_2 by the end of the first year.



Sagittal view through the lumbar vertebrae and sacrum

The line joining the two superior iliac crests (inter-cristal /Tuffier's line) crosses at L_5-S_1 interspace at birth, L_5 vertebra in young children and L_3-L_4 interspace in adults[10]. It is for this reason that lumbar puncture should be performed at a level below which the cord ends, safest being at

or below the inter-cristal line. The distance between the skin and the subarachnoid space is influenced by age – from 10 to 15mm in newborns.

The distance between skin and subarachnoid space can be related to height or weight using the formulae[10,14]:

Distance from skin to subarachnoid space (cm)= 0 03xheight (cm)

Distance from skin to subarachnoid space (mm) = (2 x weight) + 7

Depth of sub-arachnoid space from skin

Cerebrospinal fluid is a clear body fluid that occupies the subarachnoid space and the ventricular system of the brain and spinal cord.

Cerebrospinal fluid volume at different periods of life[10]

Neonates	-	10 ml/kg
Infants less than 15kg	-	4 ml/kg
Young children	-	3 ml/kg
Adolescent /Adult	-	1.5 – 2 ml/kg

CSF Volume(ml/kg) changes with age

The volume of distribution of drugs injected into the subarachnoid space is higher in infants and neonates than in adults and consequently the injected dose is relatively greater in infants and neonates. The volume

of cerebrospinal fluid in the neonate is 4ml/kg, which is double the adult volume[10,13]. Moreover, in infants half of this volume is in the spinal space whereas adults have only one-fourth. The greater volume of CSF and higher turnover account for the much shorter duration of subarachnoid block, with any given agent, as compared with adults.

PHYSIOLOGIC RESPONSE TO SPINAL ANAESTHESIA

Local anaesthetic solution injected into the subarachnoid space blocks conduction of impulses along all nerves with which it comes in contact, although some nerves are more easily blocked than others. There are three classes of nerve: motor, sensory and autonomic. Stimulation of the motor nerves causes muscles to contract and when they are blocked, muscle paralysis results. Sensory nerves transmit sensations such as touch and pain to the spinal cord and from there to the brain, whilst autonomic nerves control the calibre of blood vessels, heart rate, gut contraction and other functions not under conscious control[12].

ERLANGER-GASSER CLASSIFICATION OF NERVE FIBRES[12]

Fibre Type	Diameter	Myelin	Velocity	Function
A-alpha	13-22 um	+	70-120 m/s	Motor, proprioception
A-beta	8-13um	+	40-70 m/s	Touch, kinesthesia
A-gamma	4-8um	+	15-40 m/s	Efferent to muscle spindle
A-delta	1-4um	+	5-15 m/s	Pain, pressure temperature
B	1-3um	-	3-14 m/s	Pre-ganglionic sympathetic
C	0.4-1.2um	-	0.2-2.0 m/s	Post-ganglionic, pain, touch, temperature

Generally, autonomic and sensory fibres are blocked before motor fibres. This has several important consequences. For example, vasodilation and a drop in blood pressure may occur when the autonomic

fibres are blocked and the patient may be aware of pressure or movement and yet feel no pain when surgery starts.

DIFFERENTIAL BLOCKADE[12]

The lowest concentration of an anaesthetic agent that blocks the conduction of nerve impulses in a reasonable time is termed C_m or the minimal anaesthetic concentration. On the basis of differing C_m values of local anaesthetics for different nerve fibres, selective blockade of certain fibres and their function without blockade of other fibres can be accomplished. This is called **differential nerve block**. In the subarachnoid space, it appears that the B-fibres containing pre-ganglionic autonomic fibres are blocked quickly and by a C_m similar to that of small A-fibres.

Order of blockade following subarachnoid anaesthesia[12]:

Vasomotor
Cold temperature
Warmth
Slow pain
Fast pain
Motor
Joint sense / Proprioception
Pressure

Generally, autonomic blockade is 2 dermatomes cephalad to sensory blockade, which is in turn 2 dermatomes cephalad to the level of motor blockade.

Physiologic effects of subarachnoid anaesthesia include the following:

1. Hypotension due to – vasomotor paralysis
   - loss of skeletal muscle tone
   - direct effect on medullary centres
   - hypoxemia of medullary centres
   - direct suppression of cardio-accelerator fibres
   - adrenal paralysis
2. Bradycardia
3. Effect on respiratory muscles
   - intercostal muscle paralysis with higher levels
   - bronchial spasm with higher level due to predominant vagal activity
4. Gastro-intestinal function
   - Promotes gastric peristalsis
5. Suppression of the endocrine stress response

CARDIOVASCULAR SYSTEM

Cardiovascular changes related to subarachnoid anaesthesia are less common in children than in adults. This is attributed to the immature sympathetic nervous system in children less than 2 years of age. Also full maturity of the autonomic nervous system is not attained until 8-10 years of age. This obviates the need for volume loading prior to performing a subarachnoid block. In children under 5 years of age, minimal changes in heart rate and blood pressure have been reported[16]. Cardiovascular changes due to spinal block, if they occur, are short lasting and respond to a bolus of intravenous fluid (10ml/kg). Cardiovascular stability in infants undergoing subarachnoid anaesthesia is probably related to smaller venous capacitance in the lower limbs leading to less blood pooling[16], and to relative immaturity of the sympathetic nervous system resulting in less dependence on vasomotor tone to maintain blood pressure.

RESPIRATORY EFFECTS

Respiratory effects of SA are generally seen in association with high motor block above T_6. Children with severe chronic lung disease should receive supplemental oxygen or Continuous Positive Airway Pressure (CPAP) during subarachnoid anaesthesia[9,18].

The physiological impact of sympathectomy is minimal or none in smaller age groups. The fall in blood pressure and a drop in the heart rate are practically not seen in children less than five years. Therefore there is

no role of preloading with fluids before a subarachnoid block. This may be due to the immature sympathetic nervous system in children younger than five–eight years as a result of the relatively small intravascular volume in the lower extremities and splanchnic system limiting venous pooling and relatively vasodilated peripheral blood vessels. Infants respond to high thoracic spinal anaesthesia by reflex withdrawal of vagal parasympathetic tone to the heart. It is one of the reasons why spinal anaesthesia has been the technique of choice in critically ill and moribund neonates who present for surgery in grave haemodynamic instability.

TESTING LEVEL OF BLOCKADE

1. Testing for sensory level[12]

    a. Pinprick- 2 dermatomes cephalad to loss of touch

    b. Cold stimulus-one dermatomal segment higher than pinprick

Sympathetic block extends three or more dermatomes above loss of pinprick sensation. Regression from the time of onset of maximum analgesia to complete disappearance of analgesia is to be observed, though intermediate times such as

a. Regression by two segments and

b. Regression to T_{10} or T_{12} appear to be more relevant.

2. Assessment of motor block[12]

a. Sequence and onset of block: **Modified Bromage Scale** (modified by Logan-Wildsmith)

Modified Bromage Scale

Scale	Criteria	Block degree
0	Free movement of legs and feet, with ability to raise extended leg	None
1	Inability to raise extended leg and knee flexion is decreased, but full flexion of feet and ankles	Partial,33%
2	Inability to raise leg or knees, flexion of ankle and feet present	Partial,66%
3	Inability to raise leg, flex knee or ankle, or move toes	Complete

b. Recovery from motor blockade: **Bromage Scale**

Scale	Degree of block	Criteria
I	Complete	Unable to move feet or knees
II	Almost complete	Able to move feet only
III	Partial	Just able to flex knees
IV	None	Full flexion of knees and feet

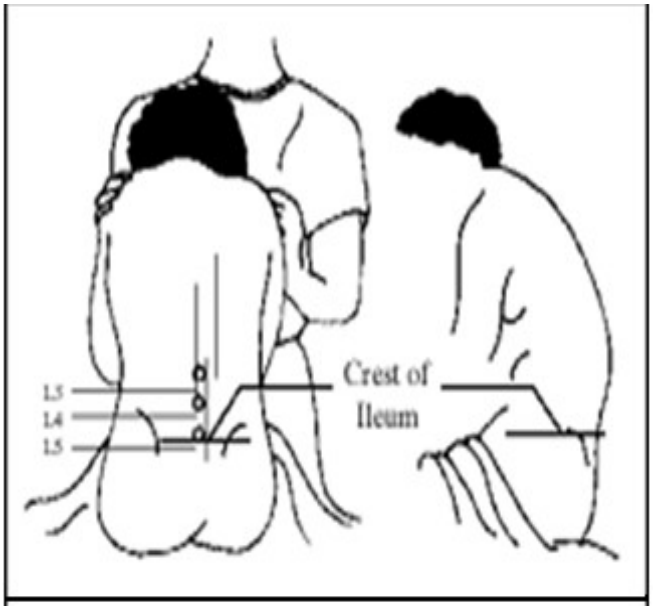
3.Assessment of sympathetic blockade

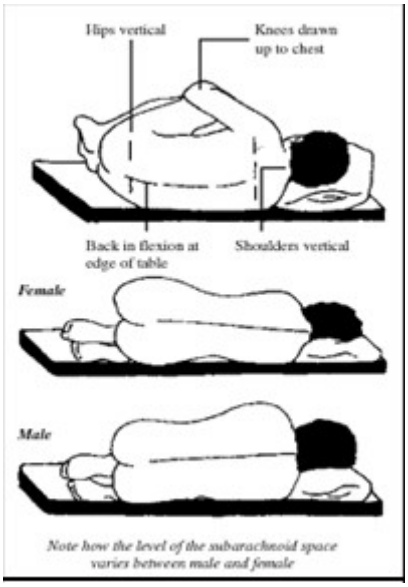
a. Sympatho-galvanic reflex

b. Measuring skin temperature- rise in temperature below the level of block

POSITIONING FOR SPINAL ANAESTHESIA

Subarachnoid anaesthesia in adults is performed in a position of universal flexion in either the sitting or lateral decubitus position[12]. One must ensure neutral position of the operating table, shoulders in a vertical plane and the presence of an assistant to hold and reassure the patient and also to ensure that the patient's airway is free. While performing the procedure in the sitting position, the assistant holds the patient's shoulders to prevent slouching.





Subarachnoid anaesthesia in children can be performed in either position. In older children, the lateral decubitus position is preferred because it provides better control. Distraction methods can be used to allay anxiety and an experienced anaesthesiologist is required to perform the technique quickly, gently and effectively.

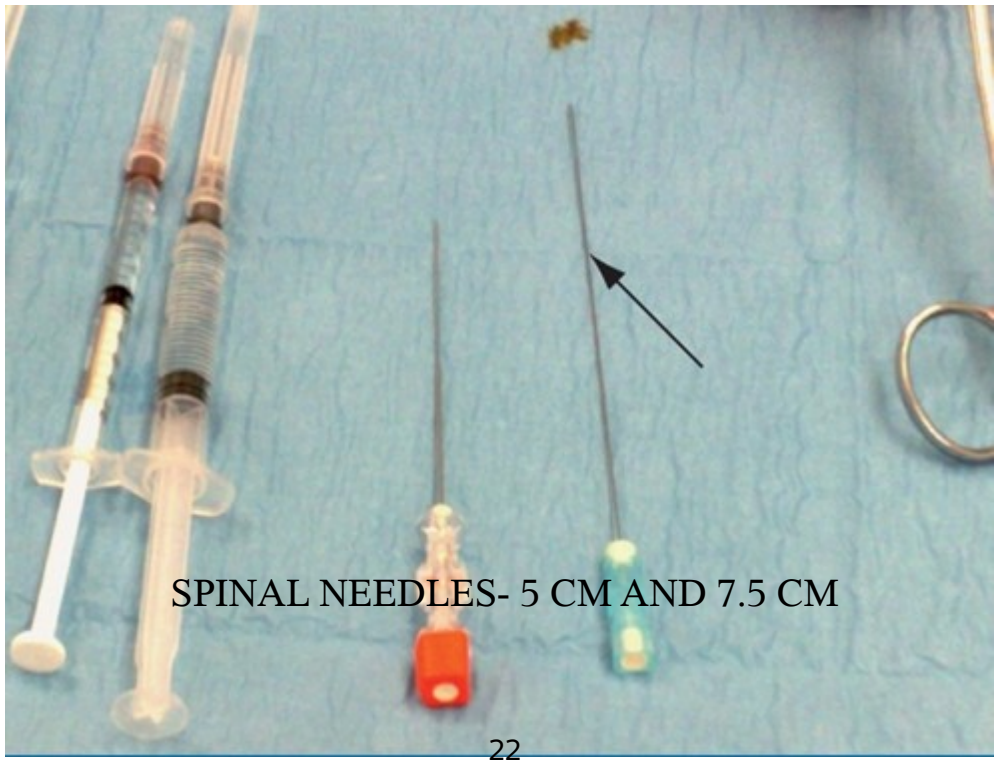
Subarachnoid anaesthesia in neonates and infants[19] can be performed in either the sitting or lateral decubitus position. The

anaesthesiologist performing the procedure should ensure that the airway is free and avoid extreme flexion of the neck as this tends to obstruct the airway. One must also observe the neonate's respiratory pattern and monitor oxygen saturation during the procedure.

NEEDLES FOR SUBARACHNOID ANAESTHESIA

Spinal needles are classified as[12]:

1. Dural-cutting - Quincke-Babcock needle
   - Pitkin needle
2. Dural-splitting - Whitacre needle
   - Sprotte needle
   - Greene needle



SPINAL NEEDLES- 5 CM AND 7.5 CM

These needles are available in different sizes ranging from 18G to 30G. Also spinal needles are available in different lengths- 5cm, 7.5cm, 9cm and 11cm. The shorter needles, when used in paediatric practice, allow easy insertion and also reduce the dead-space innate to the needle. An average 9cm spinal needle of 25G has a dead-space of roughly 0.06ml[35]. This will result in less than the calculated volume of drug reaching the subarachnoid space, especially of significance in paediatric spinal anaesthesia.

The incidence of Post-Dural Puncture Headache (PDPH) initially thought to be negligent in infants and children has now been proven to be comparable to that in adults[21-24]. The apparent lower incidence arises from gross under-reporting of complaints and failure to recognize symptoms; although no difference in incidence has been reported between dural-cutting and dural-splitting needles of similar gauge.

PHARMACOLOGY

The choice of local anaesthetic for subarachnoid administration is determined by the differences between adults and children with regard to pharmacology, physiology and appropriate dosing[25]; the most important difference is the increased risk of toxicity. Infants younger than 2 months are particularly at risk because of immature hepatic metabolism and decreased plasma proteins such as albumin and alpha-1-glycoprotein. This results in increased serum concentrations of the unbound amide local anaesthetics, especially bupivacaine and ropivacaine, which are normally 90% protein-bound. Infants also have decreased levels of plasma pseudocholinesterase that theoretically could increase the risk of toxicity with ester local anaesthetics.

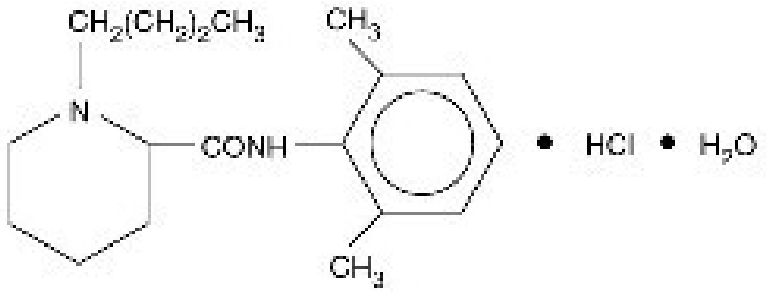
All children may be at increased risk of local anaesthetic toxicity because of the rapid increase in blood levels of local anaesthetic that may occur as a result of the relatively high cardiac output and regional blood flow that are present in this age group[9.13.26].

Anaesthetic	Plain(mg/kg)	With epinephrine(mg/kg)
Lidocaine	7	5
Bupivacaine	3	3
Ropivacaine	3	3

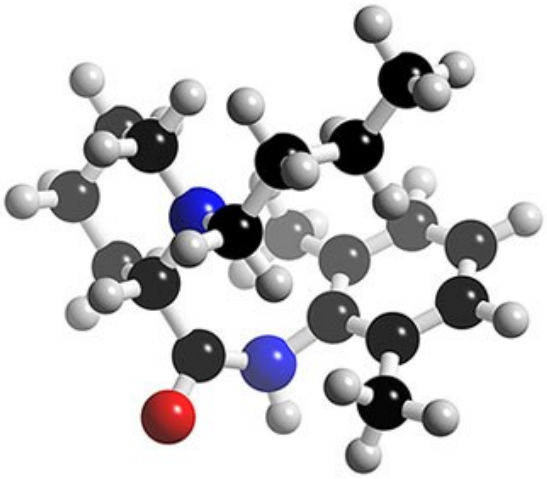
Bupivacaine is a long-acting amide local anaesthetic marketed as a racemic mixture with a pK_a of 8.1 and >95% protein binding. When given directly intravenous, bupivacaine saturates protein-binding sites on alpha-1-glycoprotein resulting in increased free fraction. Bupivacaine binds

avidly to cardiac sodium-ion channels, strongly and constantly even during diastole, causing greater cardiac toxicity than neurotoxicity. This is in contrast to lignocaine which manifests with signs of neurotoxicity before cardiac symptoms.

CHEMICAL STRUCTURE OF BUPIVACAINE



SCHEMATIC STRUCTURE OF BUPIVACAINE



Bupivacaine is used as a 0.5%solution for subarachnoid anaesthesia made hyperbaric by the addition of 8% dextrose. The dose for subarachnoid anaesthesia in adults is determined by the height of the patient and the level of blockade required for surgery.

On the contrary, in children the dose is determined by the weight of the child. A generally accepted weight-based dosing schedule is[26]:

Children weighing <5 kg : 0.5 mg/kg

Children weighing 5-15 kg : 0.4 mg/kg

Children weighing >15 kg : 0.3 mg/kg

Metabolism of bupivacaine involves hepatic aromatic hydroxylation, N-dealkylation, amide hydrolysis and further metabolism by conjugation reactions to N-desbutylbupivacaine, which lacks intrinsic activity and is water- soluble to be eliminated by the kidneys.

REVIEW OF LITERATURE

1. **Elisabeth Giaufre MD**, Risks and complications of regional. Anaesthesia in children, Bailliere's Clinical Anaesthesiology 14(4): 659-671, 2000. The study was designed to assess and quantify the risks associated with regional anaesthesia in children. Risks relating to patient factors, technique factors and operator factors are described. Spinal anaesthesia is used in patients as young as neonates and preterm neonates. In children aged<10 years, the author recommends 25G Atraucan or pencil-point needles to reduce the incidence of PDPH. Also the drug used for spinal anaesthesia is 0.5% Bupivacaine-isobaric or hyperbaric- up to a maximum dose of 1 mg/kg in children weighing less than 20 kg. Neurologic complications in the form of perioral twitches and seizures were more commonly encountered compared to cardiovascular complications.

2. **Hannu Kokki MD, PhD**, Spinal anaesthesia in infants and children Bailliere's Clinical Anaesthesiology 14(4): 687-707, 2000. The author described the use of spinal anaesthesia for day-care procedures in children. Spinal anaesthesia was given to children under sedation using 25-27G needles; the incidence of post-punctural headache was found to be 3-4%. The authors suggest that the apparent lower incidence in this age-group is due to under-reporting rather than an absolute decrease in incidence. The drug used was either Tetracaine or hyperbaric Bupivacaine. The dose of Bupivacaine was determined by

weight: children weighing under 10kg were given 0.5-0.6 mg/kg, between 10-20 kg were given 0.4mg/kg and children weighing over 20 kg were given 0.3-0.4 mg/kg. Sensory level was checked using electrical stimulator and averaged T_6. High sensory levels were not reported when using larger doses of Bupivacaine- up to 0.5mg/kg in older children.

3. **Shinichi Sakura, MD et al**, Spinal Anaesthesia with Tetracaine in 7.5% or 0.75% Glucose in Adolescents and Adults; Anaesthesia & Analgesia 2001;93:77–81. The authors evaluated the impact spinal anaesthesia on haemodynamic stability in older children and adolescents aging between 4-18 years. The children received a crystalloid preload of 10ml/kg prior to the block. A fall in systolic blood pressure over 25% from baseline was treated with a fluid bolus and a dose of Ephedrine 5mg. The authors observed the relative stability of haemodynamics in children aged 4-11 years compared to adolescents who demonstrated a more consistent fall in blood pressure. Checking of sensory level was done by pin-prick for pain and alcohol-soaked swab for cold perception.

4. **Ludmyla Kachko et al**, Spinal Anaesthesia in neonates and infants- A single-centre experience of 505 cases; Paediatric Anaesthesia 2007, 17: 647-653. Spinal anaesthesia was used for infants less than 7 months for lower abdominal, perineal, urologic and lower extremity surgeries. Level of blockade was checked by pin-prick for sensory

level and presence of profound motor blockade. They defined hypotension as greater than 20% decrease in systolic blood pressure from baseline. Bradycardia: heart rate<100 beats/min. Apnoea was defined as a sustained respiratory pause of 15sec or longer or less than 15sec if accompanied by oxygen saturation less than 90% or Bradycardia. Hypoxemia was defined as oxygen saturation below 90%.

5. **Cote Ryan Todres**: A Practice of Anaesthesia in Infants and Children; III edition 636-669. Spinal anaesthesia is recommended for preterm and term neonates and infants. Among older children, it is especially indicated for children undergoing day-care procedures. Hypotension associated with spinal anaesthesia is uncommon in children younger than 8 years because of the relative immaturity of the sympathetic nervous system and due to the relatively lower blood volume distributed to the lower extremities. Post-dural puncture headache is less common in children younger than 13 years of age.

6. **Dr.Dilip Pawar**, Regional Anaesthesia in Paediatric Patients; Indian Journal of Anaesthesia 2004; 48(5): 394-399. Use of regional anaesthesia offers complete pain relief, reduces anaesthetic requirement and provides for post-operative analgesia. Spinal anaesthesia is performed in the lateral decubitus position at a lower level: L_4-L_5 or L_5-S_1 . Incidence of PDPH is as high as in adults and is grossly under-reported.

7. **John B.Rose**, Revista Mexicana de Anestesiologia Vol.27, Supp.1 2004. Regional anaesthesia in the paediatric age-group is to be performed after sedation because it provides a calm, controllable child.

8. **Hannu Kokki et al**, Hyperbaric Buivacaine for spinal anaesthesia in 7-18 yr old children: comparison of Bupivacaine 5mg/ml in 0.9% and 8% glucose solutions. British Journal of Anaesthesia 84(1): 59-62, 2000. 107 children undergoing lower abdominal and lower extremity procedures were studied. The children were pre-loaded with 5-10 ml/kg of normal saline. Midazolam 0.5 mg/kg was used as oral premedication 45 minutes prior to surgery. Anticholinergic premedication was not routinely used. EMLA was used at venepuncture and lumbar puncture sites for topical anaesthesia. The average sensory level with hyperbaric bupivacaine was T_4, average time to regression by 2-dermatomes was 85 minutes and time to first dose of rescue analgesic was 181 minutes (120-279min).

9. **Bang-Vojdanovski B**., 10 years of spinal anaesthesia in infants and children for Orthopaedic surgery; Anaesthetist. 1996 Mar; 45(3):271-7 Children aged between 0-15 years were subjected to spinal anaesthesia using hyperbaric 0.5% bupivacaine ranging from 0.5-1.0 mg/kg. Haemodynamics were observed to be stable intra-operatively. Level of blockade was checked by pin-pricks and Bromage schema.

10. **Hannu Kokki et al**, Post-dural Puncture headache and transient neurologic symptoms after spinal anaesthesia using cutting and pencil-point paediatric spinal needles. Acta Anaesthesiology Scandinavica, 1998 Oct; 42(9): 1076-82. Children aged 2months to 10 years were given spinal anaesthesia comparing 25G Quincke needles and 26G Atraucan needles versus 27G Whitacre and 24G Sprotte needles. They concluded that though the incidence of PDPH was comparable to that in adults, no difference was noticed between dural-cutting and dural-splitting needles.

11. **Lindo JO Rice, John T.Britton**; Anaesthesiology Clinics of North America Volume 10, Number 1: 129-142, March 1992. The author recommends the use of hyperbaric 0.5% bupivacaine at a dose of 0.5-0.6mg/kg in older children up to 11 years of age.

12. **Hannu Kokki et al**; Spinal anaesthesia for paediatric day-case surgery: a double-blind, randomised, parallel group, prospective comparison of Isobaric and Hyperbaric Bupivacaine. British Journal of Anaesthesia 1998; 81: 502-506. Children aged 2-115 months were subjected to spinal anaesthesia following a premedication of 0.5 mg/kg Diazepam. EMLA cream was used for topical anaesthesia. 10ml/kg of normal saline was administered intravenously. The dose used was 0.3-0.4 mg/kg in children weighing more than 20kg. Their observed height of sensory blockade was T_4 and time to 2-segment regression was 80minutes. Time to first analgesic rescue was 110 minutes (53-270) with hyperbaric bupivacaine.

13. **Elisabeth Giaufre, Bernard Dalens, Anne Gomdert**; Epidemiology and Morbidity of Regional Anaesthesia in Children: A One-year Prospective Survey of the French-Language Society of Paediatric anaestheisologists, Anaesthesia & Analgesia 1996; 83:904-912. Spinal anaesthesia in the 3-12yr age-group using 0.5 mg/kg was less common than caudal anaesthesia in the same age-group. But the incidence of reported complications was very less. A 2/1000 morbidity in the form of intravascular injection was reported, though not associated with any clinical effects.

14. **Blaise G.A**.; Spinal Anaesthesia in Children: Anaesthesia & Analgesia 63: 227-230, 1984. Patients aged between 7weeks and 13 years were given spinal anaesthesia. Hyperbaric Bupivacaine at a dose of 0.4mg/kg was used providing an average block height at T_7. The children were preloaded with 6ml/kg of Ringer's Lactate solution after an oral premedication of 0.1mg/kg two hours pre-operatively. Level of blockade was checked by bilateral pin-prick.

PILOT STUDY

The study was undertaken entirely in the Department of Anaesthesiology, Government Stanley Medical College and Hospital, Chennai during the period from February 2009 to July 2009 with due permission from the Institutional Ethical Committee and the Head of Department, Paediatric Surgery. A Pilot Study was first conducted to define the population and decide on the criteria for patient selection and exclusion, and the number of subjects required in each group.

CRITERIA FOR PATIENT SELECTION

Children of either sex aged between 5 and 12 years belonging to ASA Physical Status I/II.

Exclusion Criteria include:

- Parental refusal
- Children with congenital malformations altering the surface anatomy
- Known coagulopathy
- Infection at the site of injection
- Generalised sepsis
- Children with known epileptic disorders or uncontrolled seizures
- Children known to have raised intracranial tension
- Children with a ventriculo-peritoneal shunt

Relative contraindication would be a child with an uncontrolled respiratory tract infection or an anticipated difficult airway.

The intended procedure was explained to the parents, all queries clarified and their due consent obtained.

MATERIALS

Materials required for the study include:

- Spinal tray- comprising of
    - 5cm 25g Quincke-Babcock
    - 9cm 25g Quincke-Babcock needles for older children
    - Sterile 2 ml syringe
    - Sterile gauze
    - Sponge-holding forceps
    - Sterile drape
    - Disinfectant solution
- Hyperbaric Bupivacaine 0.5% ampoules
- Midazolam for oral pre-medication
- Topical local anaesthetic cream Prilox
- Drugs for general anaesthesia in case of inadequate block
- Intravenous cannulae and I.V.fluids
- Emergency drugs
- Monitors- Pulse oximeter, Electrocardiogram, Non-invasive Blood Pressure

STUDY METHODS

The study was conducted as a Randomised controlled study with blinding of the patients. From the results obtained in the Pilot study, a target population of 30 subjects in each of the two groups- control and test was decided. After proper screening for the above-mentioned criteria, the parents were informed about the purpose of the study and the procedure and intended study methods the day before surgery. Parents were required to give their written consent on the morning of surgery.

Selected children were randomly assigned to two groups- labelled as B_1 and B_2. Randomisation was achieved by allotting lot numbers; odd numbers were assigned to group B_1 and even numbers to group B_2.

All children were fasted pre-operatively[4,17,26,]- 6hours for solids and 2hours for clear fluids. Oral pre-medication of Midazolam[30,34] at a dose of 0.5mg/kg[37] mixed with 5-10ml non-particulate apple juice was administered to all children one hour before the procedure. At the time of pre-medication, topical local anaesthetic cream[4,34] (Prilox- Eutectic mixture of Local Anaesthetics: Lignocaine and Prilocaine) was applied to the site of intended lumbar puncture and potential sites of venepuncture and an occlusive dressing applied.

Venous access was established with an appropriately sized cannula and Ringer lactate solution-6ml/kg infused[5,7]. Standard monitors were

attached and baseline values of heart rate, S_pO_2 and blood pressure- systolic and diastolic noted.

All measures for induction of general anaesthesia were kept ready. Keeping an eye on the saturation, the child was positioned in the lateral decubitus position. Ensuring strict asepsis, lumbar puncture was performed in the L_4/L_5 or L_3/L_4 interspace by midline approach with the appropriate spinal needle. Intrathecal position was confirmed by the free flow of clear CSF. Hyperbaric Bupivacaine was loaded in a 2ml syringe prior to performing lumbar puncture- children belonging to group B_1 receive 0.5mg/kg[17,27,32,34] and those belonging to group B_2 receive 0.3mg/kg[26]. After injection of the drug, the spinal needle was kept in position for up to 5 seconds to avoid tracking of drug[4,5,27]. On removal of the needle, the depth to subarachnoid space from skin level was noted on the shaft of the needle with a permanent marker pen.

In case of a bloody tap, we waited for the CSF to clear before injecting drug or the needle was re-inserted in a different space. Three unsuccessful attempts was labelled a failed lumbar puncture.

The child was positioned supine and the level of sensory blockade noted after 3minutes by looking for facial grimace and/or an increase in heart rate in response to pin-prick. Saturation, HR and blood pressure- systolic, diastolic and mean pressures- were noted at 5minute intervals for the first 15 minutes and every 15minutes thereafter.

HYPOTENSION: A fall in systolic blood pressure >20% from baseline was managed with a fluid bolus of up to 10ml/kg[18,32]. Fall in blood pressure that did not respond to fluids was treated with a dose of intravenous Ephedrine- 5mg.

BRADYCARDIA[18,32]: Fall in heart rate to less than 100bpm or >20% from baseline (whichever was lower) was managed with intravenous Atropine 0.02 mg/kg.

APNOEA/DESATURATION: sustained respiratory pause of 15 sec or less than 15 sec if accompanied by oxygen saturation less than 90% or Bradycardia.

ECG changes, if any were noted- particularly an increase in T-wave amplitude[10,26]- suggestive of bupivacaine toxicity as might occur after an inadvertent intravascular injection.

Inadequate sensory blockade at the end of 5minutes was labelled a Failed Spinal and converted to general anaesthesia. All cases converted to General anaesthesia were excluded from the study. An apprehensive, restless child with an adequate block was managed by mask ventilation with nitrous oxide-oxygen mixture[2,5,21,]. Incidence of complications such as high spinal and intravascular injection was noted. At the end of the procedure, the duration of surgery was noted.

All children were observed for two hours after the end of procedure in the recovery room before being shifted to the post-op ward. Time to 2-

segment regression by checking every 5 minutes and time of rescue analgesic administration, in the form of rectal Paracetamol (duration of analgesia) were noted. Post-operative complications such as apnoea, nausea, vomiting and headache were looked for and treated accordingly. Also each patient was followed until discharge.

STATISTICAL ANALYSIS

A sample size of 30 per group was decided during the pilot study. Randomisation of subjects to the two groups was done by allotting random numbers to each. Children with odd numbers were allotted to Group B_1 and those with even numbers were allotted to Group B_2.

Data was expressed as mean ± SD. Quantitative analysis was compared with student's t-test: Equal-Variance T-Test Section for comparison of discrete variables and the Aspin-Welch Unequal-Variance Test for continuous variables.

When using the student's t-test to compare the mean among the two groups, p-value of less than 0.05 was taken as significant.

The patients in each group were comparable in distribution in terms of age, weight and sex distribution.

OBSERVATIONS AND RESULTS

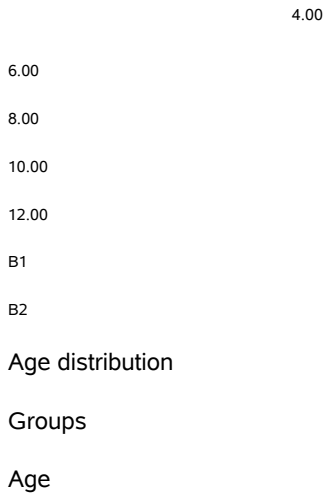
DEMOGRAPHIC VARIABLES

TABLE - 1

AGE DISTRIBUTION AMONG GROUPS B_1 AND B_2

Group	Mean (years)	Standard deviation	Standard Error	Student's t-test p value
B_1	7.0333	1.916	0.3498221	0.529986
B_2	7.35	1.965	0.3589176	Not significant

BOX PLOT



Both groups were comparable in terms of age, the average age being similar- around seven years in both groups.

TABLE - 2

GENDER DISTRIBUTION AMONG GROUPS B_1 AND B_2

No significant difference was found among the two groups in terms of gender distribution. Among the 30 children in Group B_1, 21 were boys and 9 were girls. In Group B_2, 20 were boys and 10 were girls.

TABLE - 3

WEIGHT DISTRIBUTION AMONG GROUPS B_1 AND B_2

Groups	Mean weight (kg)	Standard deviation	Standard Error	Student t-test
B_1	18.6333	4.589969	0.8380099	0.2229
B_2	20.8666	3.892816	0.5980114	Not significant

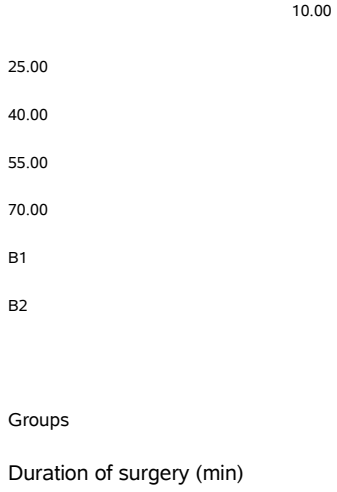
No significant difference among the two groups.

TABLE - 4

DURATION OF SURGERY AMONG GROUPS B_1 AND B_2

Groups	Mean (minutes)	Standard Deviation	Standard Error	Student's t-test p-value
B_1	27.83333	12.01173	2.193032	0.866433
B_2	27.3333	10.88603	1.987509	Not significant

BOX PLOT



Duration of surgery was comparable between the two groups- roughly twenty-seven minutes in both groups.

TABLE - 5

INTRA-OP HEART RATE VARIABILITY

INTRA-OP HEART RATE VARIABILITY

HR	Mean		Standard Deviation		Standard Error		p-value
	B_1	B_2	B_1	B_2	B_1	B_2	
Baseline	99.2666	97.8	8.9709	12.1411	1.6378	2.2166	0.5966
5 min	94.5666	97.6333	9.8634	12.1413	1.8008	2.2166	0.2870
10 min	92.8667	94.8	10.404	12.7884	1.8996	2.3348	0.5230
15 min	92.5333	94.4	8.5368	11.6784	1.5586	2.1321	0.4825
30 min	91.2	91.8	8.4134	10.5680	1.5360	1.9294	0.8086
60 min	89.5666	89.8333	8.3073	9.7912	1.5167	1.7876	0.9098

Comparison of heart rate measured at baseline, 5minute, 10 minutes, 15 minutes, 30 minutes and 60 minutes after administration showed no significant differences among the two groups. Clinically though, two children in Group B_1 and one child in Group B_2 developed significant Bradycardia- slowing of heart-rate more than 20% from baseline, which responded to intravenous Atropine 0.02 mg/kg.

TABLE - 6

INTRA-OP SYSTOLIC BLOOD PRESSURE VARIABILITY

INTRA-OP SYSTOLIC BLOOD PRESSURE VARIABILITY

Systolic Blood Pressure	Mean		Standard Deviation		Standard Error		p-value
	B_1	B_2	B_1	B_2	B_1	B_2	
Baseline	106.6	108.667	4.3990	5.2806	0.8031	0.9641	0.1051
5 min	104.433	105.667	5.5936	4.5435	1.0212	0.8295	0.1123
10 min	102.0333	102.533	5.5116	4.7686	1.0062	0.8706	0.264
15 min	101.2667	102.833	4.3938	3.6015	0.8022	0.6575	0.1363
30 min	101.9	102.7	2.9048	2.9378	0.5303	0.5363	0.293
60 min	102.867	102.133	2.9796	2.4876	0.5440	0.4541	0.305

Comparison of systolic blood pressures at baseline, 5 minutes, 10 minutes, 15 minutes, 30 minutes and 60 minutes after administration of subarachnoid block showed no significant difference among the two groups, suggesting that there was no statistically or clinically significant fall in blood pressure associated with the higher dose of hyperbaric bupivacaine.

TABLE - 7

INTRA-OP DIASTOLIC BLOOD PRESSURE VARIABILITY

INTRA-OP DIASTOLIC BLOOD PRESSURE VARIABILITY

Diastolic Blood Pressure	Mean		Standard Deviation		Standard Error		p-value
	B_1	B_2	B_1	B_2	B_1	B_2	
Baseline	68.4333	70.4666	4.040	3.3603	0.7376	0.6135	0.06835
5 min	65	68	4.6756	4.1439	0.8536	0.7565	0.0109
10 min	62.5333	66.2	5.9465	4.5818	1.0856	0.8365	0.0096
15 min	61.8333	65.2333	4.7494	3.8746	0.8671	0.7074	0.0035
30 min	62.5	64.8333	3.8840	3.9135	0.7091	0.7145	0.024
60 min	63.1333	64.7	3.3086	3.8876	0.6040	0.7097	0.098

Diastolic blood pressure variability between the two groups was found to be significant from 5minutes to 30 minutes after administration of subarachnoid block. More specifically, diastolic pressures were 4-5mmHg lower among Group B_1 subjects receiving 0.5 mg/kg of hyperbaric Bupivacaine.

TABLE - 8

LEVEL OF BLOCKADE- COMPARISON OF B_1 AND B_2

T5

T6

T7

T8

T9

B1

B2

Level of blockade

Groups

Level of Blockade	Group B_1	Group B_2
T_5	2	0
T_6	14	1
T_7	10	11
T_8	4	14
T_9	0	4

No children belonging to either group demonstrated a level higher than T_5. Children in Group B_1 demonstrated consistently higher levels of sensory blockade- T_6 on an average in group B_1 versus T_7-T_8 in Group B_2.

0.0

3.8

7.5

11.3

15.0

5.0

6.0

7.0

8.0

Histogram – Level of blockade Group B1

Level of blockade

Number

0.0

3.8

7.5

11.3

15.0

6.0

7.0

8.0

9.0

Histogram –Level of blockade GroupB2

Level of blockade

Number

Statistical analysis by the Aspin-Welch Unequal-Variance Test showed high levels of significance with p-value of 0.0001.

TABLE - 9

SUPPLEMENTATION REQUIRED

Supplementation of anaesthesia	Group B_1		Group B_2	
	Count	Percent	Count	Percent
Required	3	10%	8	26.7%
Not required	27	90%	22	73.3%

Probability level- 0.0952

Though not found to be of statistical significance, the fact that eight children receiving the conventional dose needed supplementation in the form of nitrous-oxide oxygen mixture by face-mask proves to be clinically significant. On the contrary, only 3 children in group B1 required supplementation.

Incidence of post-operative complications including headache, apnoea/desaturation and post-op nausea/vomiting was not significantly different. One child in each group developed vomiting after the surgery in the post-op recovery room. This was treated with intravenous Ondansetron 0.1 mg/kg. Both children were observed until the evening of surgery. There were no further episodes of nausea or vomiting.

TABLE- 10

TIME TO 2-SEGMENT REGRESSION

20.00

45.00

70.00

95.00

120.00

B1

B2

2-segment regression

Groups

Group	count	Mean	Standard deviation	Standard Error	Student's t-test p-value
B_1	30	91.5	12.32813	2.250798	0.00001, Significant
B_2	30	45.8333	5.884423	1.074344	

Time taken for the sensory level to regress by two segments was doubled in Group B_1, compared to that in group B_2.

TABLE - 11

TIME OF ANALGESIC RESCUE

160.0

195.0

230.0

265.0

300.0

-3.0

-1.5

0.0

1.5

3.0

Normal Probability Plot – analgesic rescue Group B_1

Expected Normals

60.0

90.0

120.0

150.0

180.0

-3.0

-1.5

0.0

1.5

3.0

Normal Probability Plot - analgesic rescue Group B_2

Expected Normals

Group	Count	Mean	Standard deviation	Standard Error	Student t-test,p-value
B_1	30	213.3333	33.40796	6.099432	0.0001, Significant
B_2	30	127	28.66573	5.233623	

Comparison of the time to first rescue analgesic after administration of subarachnoid block was prolonged in Group B_1 versus Group B_2.

DISCUSSION

Spinal anaesthesia can safely be used in children undergoing procedures in the lower abdomen and lower extremities. Our study used spinal anaesthesia for children undergoing the following procedures:

- Inguinal herniotomy : 19
- Circumcision : 18
- PV sac ligation for Hydrocele : 10
- Orchidopexy : 4
- Cystoscopy : 3
- Hypospadias repair : 1
- Lateral sphincterotomy : 1
- Miscellaneous : 4

Children belonging to Group B_1 received 0.5mg/kg of Bupivacaine while children belonging to Group B_2 received 0.3mg/kg of hyperbaric bupivacaine.

The average age in the two groups was comparable- around 7 years. The average weight in both groups was also comparable. Both groups involved surgeries of similar duration- roughly 25 minutes.

The procedure was performed with Midazolam sedation similar to that prescribed by G.A.Blaise and H.Kokki et al. Supplementation with nitrous oxide-oxygen was on the lines of that suggested by H.Kokki et al. Three children in group B_1 required supplementation, and 5 in group B2 required supplementation. None of the cases were converted to General anaesthesia.

In spite of the widely used conventional dose of 0.3mg/kg in children weighing over 15 kg, studies by Bang-Vojdanowsy[33], Lindo JO Rice et al[32] and E.Giaufre[27,34] have used higher doses up to a maximum of 1mg/kg without any increase in the incidence of haemodynamic instability or high spinal. This observation was made in our study also, where we used 0.5mg/kg of hyperbaric bupivacaine without an increased incidence of complications. This is probably attributed to the larger volume per kilogram body weight of CSF which allows for a greater volume of distribution in the intrathecal space. Also the relative immaturity of the sympathetic nervous system prevents the occurrence of gross hypotension

Pre-loading was not used by Junkin et al[36]; on the contrary, preloading with 5-10ml/kg of crystalloid was advocated by G.A.Blaise and H.Kokki. Neither study reported hypotension in the study age-group.

In our study also, there was no significant fall in systolic blood pressure which warranted active management. In our study, we observe a fall in diastolic blood pressure from 5minutes to 30 minutes after spinal.

This was managed with a fluid bolus of up to 10 ml/kg. No children required vasopressors.

None of the previous studies reported significant Bradycardia. In our study, one patient belonging to group B_2 had a significant decrease in heart rate which responded to intravenous Atropine. This was probably related to parasympathetic overdrive in response to pain due to an inadequate level of blockade.

H.Kokki et al have demonstrated an average level of blockade of T_4 with 0.3 mg/kg, while our study showed an average of T_7 with the lower dose and T_5-T_6 with the higher dose. This discrepancy is probably related to the method of checking for level of blockade. Kokki et al used Trans-cutaneous electrical stimulation to check the level.

Eight children in Group B_2 required supplementation in the form of nitrous oxide-oxygen mixture by face mask, in comparison to only three children in Group B_2.

Time to 2-segment regression was found to be significantly different in our study among the two groups. Time to 2-segment regression in earlier studies by Kokki et al, with 0.3 mg/kg, were around 65-70 minutes. Also the time to first rescue analgesic was longer. Group B_2 children required rescue analgesic at around 120 minutes, comparable to the results obtained by H.Kokki et al with the same dose. Children receiving 0.5mg/kg required a rescue analgesic much later- 210 minutes.

Post-operative complications such as apnoea, desaturation and headache were not observed in our study in either group. Post-op vomiting was seen in one child in each group which was managed with intravenous Ondansetron.

SUMMARY

In our Randomised controlled, single-blind trial involving 30 subjects in two groups; we compared the safety and efficacy of using a higher dose of hyperbaric bupivacaine in children aged between 5-12 years.

Our observations include the following:

- Spinal anaesthesia is a safe technique for providing surgical anaesthesia in children.
- Spinal anaesthesia can be used as a stand-alone technique with minimal premedication in paediatric surgery, especially for day-case procedures.
- Pre-loading was not required to prevent any fall in blood pressure
- Haemodynamic stability is the rule in children younger than 12 years.
- In children weighing over 15 kg, 0.5mg/kg can be used safely to provide a more predictable level of blockade and a longer duration of surgical anaesthesia and post-operative analgesia.

CONCLUSION

Spinal anaesthesia was demonstrated to be a safe anaesthetic technique for paediatric surgery. The rapid onset and predictable motor blockade, with minimal requirement of supplemental anaesthesia prove to be advantageous in day-case surgeries in children.

A higher dose of Hyperbaric 0.5% Bupivacaine at 0.5mg/kg body weight is found to be safe in children belonging to the 5-12 year age group and can be dependably used as the sole anaesthetic technique. There is no increased risk of complications. At the same time, the higher dose provides a more predictable height of sensory blockade and a longer duration of both surgical anaesthesia and post-operative analgesia in comparison to the conventional dose of 0.3mg/kg.

BIBLIOGRAPHY

1. Abajian JC et al: Spinal Anaesthesia for Surgery in the high risk infant; Anaesthesia & Analgesia 63: 359-362, 1984

2. Hannu Kokki et al: Comparison of Spinal Anaesthesia and General Anaesthesia; Anaesthetist 41(12): 765-768, 1992

3. Rice LJ et al: Spinal Anaesthesia does not compromise ventilation or oxygenation in high-risk infants: Anaesthesiology 71: A1021, 1989

4. Hannu Kokki, Tuovinen K., Hendolin H.: Spinal Anaesthesia for Paediatric Day-case Surgery: a Double-blind, Randomised, Parallel group, Prospective Comparison of Isobaric and Hyperbaric Bupivacaine; British Journal of Anaesthesia 1998; 81: 502-506

5. G.A.Blaise, W.L.Roy: Spinal Anaesthesia for minor paediatric surgery; Canadian Anaesthesia Society Journal 33(2): 227-230, 1986:

6. Melman E et al: Regional Anaesthesia in children: Anaesthesia & Analgesia 54: 387-390, 1975

7. Blaise G.A.; Spinal Anaesthesia in Children: Anaesthesia & Analgesia 63: 227-230, 1984

8. Busoni P., Messeri A.; Anaesthesia & Analgesia 68: 418-419, 1989 Spinal Anaesthesia in children- Surface Anatomy

9. Smith's Paediatric Anaesthesia for Infants and Children, III Edition

10. Cote Ryan Todres: A Practice of Anaesthesiology in Infants and Children, III Edition 636-669

11. Dilip Pawar: Regional Anaesthesia in Paediatrics patients; Indian Journal of Anaesthesia 48(5): 394-399, 2004

12. Collin's Textbook of Practical Anaesthesia, III Edition

13. Gregory A. Gregory: Textbook of Paediatric Anaesthesia, III Edition 287-290

14. Bonadio WA, Smith DS, Mitron M et al: New England Journal of Medicine 319: 952-953, 1988: Estimating lumbar puncture depth in children

15. Claude Saint Maurice: Dalens Regional Anaesthesia for Infants and Children, 261-273

16. Dohi S: Age-related changes in Blood Pressure and duration of motor block; Anaesthesiology 50: 319-323,1979

17. Berkowitz S: Report based on 350 patients <13 years age: Anaesthesiology 12: 376-387, 1951

18. Pascucci RC et al: Effect of Spinal Anaesthesia on chest wall displacement in infants: Anaesthesiology 69: A773, 1988

19. Gleason CA, et al: Optimal Position for Spinal Tap in Preterm neonates: Paediatrics 71:31-35, 1983

20. D.K.Turnbull, D.B.Shepherd: Post-dural Puncture Headache: pathogenesis, prevention and treatment: British Journal of Anaesthesia 91(5): 718-729, 2003

21. Hannu Kokki, Hendolin K., Turunen M.: Post-dural Puncture Headache and Transient Neurologic Symptoms in Children after Spinal Anaesthesia using cutting and pencil-point paediatric spinal needles; Acta Anaesthesiology Scandinavia 42(9): 1076-1082, October 1998

22. Hannu Kokki et al: Comparison of 25G and 29G needles in Paediatric Day-case Surgery; Acta Anaesthesiology Scandinavia 39(7): 896-900, October 1995

23. Bolder PM: Post-lumbar Puncture Headache in Paediatric Oncology patients: Anaesthesiology 65: 695-698, 1986

24. Wright T.E. et al: Complications during Spinal Anaesthesia in Infants; Anaesthesiology 73: 1290-1292,1990

25. Stoelting's Textbook of Pharmacology and Physiology in Anaesthetic Practice, IV Edition

26. Miller's Textbook of Anaesthesiology, VII Edition

27. Elisabeth Giaufre: Risks and Complications of Regional Anaesthesia in children: Bailliere's Clinical Anaesthesiology 14(4): 650-671, 2000

28. Hannu Kokki: Spinal Anaesthesia in Infants and Children: Bailliere's Clinical Anaesthesiology 14(4): 687-707, 2000

29. Shinichi Sakura et al: Spinal Anaesthesia with Tetracaine in 7.5% or 0.75% Glucose in Adolescents and Adults; Anaesthesia & Analgesia 93:77–81, 2001

30. Ludmyla Kachko et al: Spinal Anaesthesia in neonates and infants- A single-centre experience of 505 cases; Paediatric Anaesthesia 17: 647-653, 2007

31. John B.Rose: Paediatric Regional Anaesthesia is best performed with the child asleep; Revista Mexicana de Anestesiologia 27(1); 59-62, 2004

32. Lindo JO Rice, John T.Britton; Anaesthesiology Clinics of North America 10(1): 129-142, March 1992

33. Bang-Vojdanovski B et al: 10 years of Spinal Anaesthesia in Infants and Children for Orthopaedic Surgery: Anaesthetist 45(3): 271-277, March 1996

34. Elisabeth Giaufre, Bernard Dalens, Anne Gombert: Epidemiology and morbidity of Regional Anaesthesia in Children: A one-year Prospective Survey of the French-Language Society of Paediatric Anaesthesiologists: Anaesthesia and Analgesia 83:904-912, 1996

35. Oxford Handbook of Anaesthesia, II Edition

36. Junkin CI: Spinal Anaesthesia in Children, Canadian Medical Associate Journal 51-53, 1933

37. Almenrader N. et al: Premedication in children: a comparison of oral Midazolam and oral Clonidine; Paediatric Anaesthesia 17(12): 1143-1149, December 2007

PROFORMA

Name : Group assigned : B_1 / B_2

Age/Sex/Weight :

IP.Number :

Diagnosis :

Surgery planned :

ASA Status : Associated Medical conditions:

Last oral intake :

Oral Pre-medication-Diazepam 0.1mg/kg- Time:

Topical local anaesthetic cream Time:

Shifted to theatre Time:

Venous access secured Time:

Monitors- baseline values: HR -

SpO2-

BP -

Positioning : Time:

Lumbar puncture : Number of attempts:

Drug injected- Time :

Supine positioning :

Sensory level (response to pin-prick) :

Number of attempts :

Failed LP :

Failed Spinal :

Depth of insertion :

Intra-op complications

- Apnoea/ desaturation :
- Bradycardia :
- Hypotension :
- High spinal :
- Supplementation :

Duration of surgery :

Time to regression by 2-dermatomes:

Time to rescue analgesic:

Post-op complications

- Apnoea :
- Headache :
- PONV :

DEMOGRAPHIC DATA- GROUP B_1

S. No	Name	Age	Sex	IP.No	Surgery	PS	Wt kg	Dose mg	Attempts
1.	Swetha	5	F	11099	Cystoscopy	I	16	8	1
2.	Akash	5	M	10006	Circum	I	15	7.5	1
3.	Rajesh	10	M	10287	Orchidopex	I	20	10	2
4.	Sriram	6	M	11110	Circum	I	14	7	1
5.	Manoj	5	M	11003	PV sac lig	I	15	7.5	1
6.	Kamesh	6	M	10108	PV sac lig	II	15	7.5	1
7.	Dinesh	7	M	10312	Circum	I	16	8	1
8.	Ramya	5	F	10128	Herniotomy	I	15	7.5	2
9.	Nivedha	9	F	11113	Herniotomy	II	22	11	1
10.	Ranjith	6	M	11370	Circum	I	18	9	2
11.	Anwar	6.5	M	11184	Orchidopex	I	20	10	1
12.	Sairam	7	M	11090	Cystoscopy	II	22	11	1
13.	Varun	9	M	10356	PV sac lig	I	26	13	1
14.	Aswin	5	M	10285	PV sac lig	I	12	6	1
15.	Manish	5	M	12903	Hypospadias	I	15	7.5	1
16.	Ranjini	6	F	10374	Herniotomy	I	16	8	1
17.	Sanjay	11	M	10192	Circum	I	28	14	1
18.	Vikram	10	M	10023	Herniotomy	II	30	15	1
19.	Vineeta	6	F	12995	Herniotomy	I	18	9	1
20.	Mujibur	7	M	13890	Circum	I	20	10	1
21.	Rashmi	9	F	11002	Herniotomy	I	20	10	1
22.	Harish	6	M	10769	PV sac lig	I	14	7	1
23.	Murali	7	M	10273	Circum	II	16	8	1
24.	Padmini	11	F	10165	Herniotomy	II	27	13	1
25.	Priyank	7	F	10087	Lat. Sphinc	II	20	10	1
26.	Darsini	10	F	11747	Herniotomy	II	24	12	1
27.	Raghu	5	M	10118	Circum	I	15	7.5	1
28.	Niyatha	6	F	10092	Bursitis	I	16	8	1
29.	Pandian	7	M	12876	Circum	I	16	8	1
30.	Prabhu	6.5	M	10196	Ganglion	I	18	9	1

GROUP B_1- DATA

Sl. No	Heart Rate						Depth	Level	Sx durn	Suppl	Faild LP	Faild spinl
	bas	5m	10	15	30	60						
1.	118	114	112	104	106	104	2.8	T_7	20	N	N	N
2.	102	98	98	97	92	90	2.2	T_6	20	N	N	N
3.	92	88	84	86	80	80	2.6	T_6	65	N	N	N
4.	88	88	84	86	84	80	2.7	T_8	20	N	N	N

5.	110	115	116	102	98	98	2.2	T_6	40	Y	N	N
6.	120	104	82	106	110	112	2.8	T_8	35	N	N	N
7.	102	98	96	96	96	90	2.9	T_7	20	N	N	N
8.	108	102	96	95	97	92	2.4	T_6	30	N	N	N
9.	96	99	105	92	90	90	2.9	T_7	40	Y	N	N
10.	106	72*	102	98	96	92	2.9	T_6	15	N	N	N
11.	98	92	92	90	88	89	2.7	T_7	40	N	N	N
12.	94	88	89	88	84	84	2.9	T_6	25	N	N	N
13.	92	86	86	87	84	84	3.2	T_6	30	N	N	N
14.	95	95	92	88	89	85	2.9	T_7	35	N	N	N
15.	108	103	102	98	96	95	2.8	T_6	45	N	N	N
16.	106	102	99	96	95	95	2.7	T_7	25	N	N	N
17.	84	82	80	72	74	74	3.1	T_8	15	N	N	N
18.	88	82	80	82	78	79	3.3	T_6	35	N	N	N
19.	98	95	96	92	92	90	2.7	T_6	40	N	N	N
20.	102	98	95	97	94	92	2.8	T_7	15	N	N	N
21.	98	83	66*	112	102	100	2.8	T_5	35	Y	N	N
22.	102	105	100	96	96	94	2.5	T_6	20	N	N	N
23.	94	96	90	88	88	85	2.7	T_7	15	N	N	N
24.	96	93	92	90	90	90	3.1	T_5	40	N	N	N
25.	86	83	84	80	84	82	2.8	T_6	15	N	N	N
26.	88	84	85	83	80	78	3.2	T_6	25	N	N	N
27.	108	105	106	102	101	98	2.7	T_7	15	N	N	N
28.	105	101	96	96	96	93	2.6	T_8	25	N	N	N
29.	102	96	95	95	94	92	2.7	T_6	15	N	N	N
30.	92	90	86	82	82	80	2.7	T_7	20	N	N	N

*- two episodes of significant Bradycardia- responded to intravenous Atropine 0.02mg/kg.

GROUP B_1- DATA

Sl. No	Name	Systolic Blood Pressure						Diastolic Blood Pressure					
		bas	5m	10m	15m	30m	60m	bas	5 m	10 m	15 m	30 m	60 m
1.	Swetha	100	100	90	90	100	102	60	60	60	60	60	58
2.	Akash	107	102	98	99	100	104	62	65	60	59	62	63
3.	Rajesh	112	110	104	106	103	106	69	67	60	62	64	62
4.	Sriram	102	97	96	98	101	101	65	63	58	60	62	63
5.	Manoj	104	107	97	96	98	100	66	64	56	55	55	59
6.	Kamesh	103	96	94	98	100	102	65	54	50	57	59	60
7.	Dinesh	109	104	103	100	101	103	68	62	62	60	62	64
8.	Ramya	101	96	97	100	100	104	62	54	55	62	60	62
9.	Nivedha	110	115	116	100	102	104	68	70	72	66	65	64
10.	Ranjith	104	92	98	98	100	102	70	60	64	59	62	60
11.	Anwar	105	102	100	100	100	101	68	60	62	58	60	65
12.	Sairam	109	105	106	104	104	105	70	67	63	61	62	63
13.	Varun	110	113	107	106	105	106	72	70	68	64	60	60

14.	Aswin	104	103	100	101	102	102	68	67	58	59	60	61
15.	Manish	102	102	98	98	99	100	64	60	56	55	57	60
16.	Ranjini	103	101	98	99	100	100	66	61	54	56	57	59
17.	Sanjay	114	112	108	106	107	100	76	70	70	68	70	68
18.	Vikram	120	116	112	114	110	112	80	74	78	74	72	70
19.	Vineeta	105	104	101	99	104	104	68	66	62	60	67	68
20.	Mujibur	108	108	108	105	105	103	68	68	66	63	67	68
21.	Rashmi	110	107	102	100	102	106	70	69	65	68	66	68
22.	Harish	102	100	100	99	98	103	70	63	63	60	60	59
23.	Murali	107	105	108	104	103	97	68	68	66	60	62	64
24.	Padmini	110	108	107	106	105	106	70	69	70	66	67	65
25.	Priyanka	105	104	105	106	102	106	70	66	67	69	64	65
26.	Darshini	112	110	106	106	107	103	69	71	69	72	68	68
27.	Raghu	104	104	100	100	99	100	68	65	58	59	60	61
28.	Niyatha	105	102	99	99	100	100	69	66	60	59	61	64
29.	Pandian	107	104	102	100	100	101	66	66	62	60	62	60
30.	Prabhu	104	104	100	101	99	100	67	65	62	64	62	63

GROUP B_1- DATA

Sl. No	Name	Post-op complications			2-segment regression	Rescue analgesic
		PONV	Apn/desat	Headache		
1.	Swetha	N	N	N	90	200
2.	Akash	N	N	N	70	220
3.	Rajesh	N	N	N	90	180
4.	Sriram	N	N	N	100	250
5.	Manoj	N	N	N	105	230
6.	Kamesh	N	N	N	95	165
7.	Dinesh	N	N	N	70	170
8.	Ramya	N	N	N	75	190
9.	Nivedha	N	N	N	85	225
10.	Ranjith	N	N	N	75	250
11.	Anwar	N	N	N	80	230
12.	Sairam	N	N	N	95	240
13.	Varun	N	N	N	90	175
14.	Aswin	N	N	N	85	205
15.	Manish	N	N	N	80	180
16.	Ranjini	N	N	N	90	200
17.	Sanjay	N	N	N	110	285
18.	Vikram	N	N	N	120	280
19.	Vineetha	N	N	N	110	265
20.	Mujibur	N	N	N	90	240
21.	Rashmi	Y	N	N	110	240
22.	Harish	N	N	N	95	210
23.	Murali	N	N	N	90	195
24.	Padmini	N	N	N	105	225

25.	Priyanka	N	N	N	90	190
26.	Darshini	N	N	N	100	240
27.	Raghu	N	N	N	85	175
28.	Niyatha	N	N	N	90	190
29.	Pandian	N	N	N	80	170
30.	Prabhu	N	N	N	95	190

DEMOGRAPHIC DATA- GROUP B_2

S. No	Name	Ag	Sex	IP.No	Surgery	PS	Wt kg	Dose mg	Attempts
1.	Praveen	11	M	11019	Circum	II	25	7.5	1
2.	Sidharth	8	M	10238	Circum	I	18	5.5	1
3.	Barath	9	M	12364	Orchidopex	II	25	7.5	1
4.	Mahmud	6	M	10028	PV sac lig	I	21	6	1
5.	Rajkumr	5	M	10001	Herniotomy	I	15	4.5	1
6.	Prasanna	7	M	10108	Circum	I	22	6.5	2
7.	Ajay	6.5	M	16398	Circum	I	24	7	1
8.	Saifulla	8	M	17730	Herniotomy	II	25	7.5	1
9.	Lavanya	6	F	16029	FB foot	I	20	6	1
10.	Iswarya	7	F	12710	Herniotomy	I	24	7	1
11.	Gayatri	8	F	12681	Exostosis	I	22	6.5	1
12.	Harsha	7	M	17610	Circum	I	22	6.5	1
13.	Preetha	6	F	10781	Herniotomy	I	20	6	1
14.	Raghav	5	M	19800	Orchidopex	II	17	5	1
15.	Aruna	6	F	10988	Herniotomy	II	18	5.5	1
16.	Arjun	5.5	M	17812	PV sac lig	I	16	5	1
17.	Saktivel	6	M	19892	Circum	I	17	5	1
18.	Nizam	9	M	12673	PV sac leg	I	26	8	1
19.	Victor	5	M	12675	Herniotomy	I	16	5	1
20.	Akshay	10	M	12928	Circum	II	26	8	1
21.	Keziya	11	F	11673	Herniotomy	I	22	6.5	2
22.	Stephen	10	M	15142	Circum	I	21	6	1
23.	Anu	8	F	11283	Herniotomy	I	23	7	1
24.	Kavitha	6.5	F	09373	Herniotomy	I	18	5.5	1
25.	Jayanth	6	M	10193	PV sac lig	I	16	5	1
26.	Prem	5	M	14748	PV sac leg	I	14	4	1
27.	Gautam	7	M	13I33	Herniotomy	I	18	5.5	1
28.	Pradeep	11	M	11335	Cystoscopy	I	27	8	1
29.	Kavya	10	F	13162	ing node Bx	I	28	8.5	1
30.	Madhav	5	M	12135	Circum	I	20	6	1

GROUP B_2- DATA

Sl. No	Heart Rate						Depth	Level	Sx durn	Suppl	Faild LP	Faild Spinl
	bas	5m	10	15	30	60						
1.	92	96	90	88	88	84	3.3	T_8	15	N	N	N
2.	82	88	87	84	80	80	2.9	T_7	25	Y	N	N
3.	102	92	64*	112	102	96	3.1	T_8	30	Y	N	N
4.	92	95	99	102	93	93	2.8	T_7	35	Y	N	N
5.	110	116	114	111	106	107	2.7	T_7	45	Y	N	N
6.	106	100	96	97	99	93	2.8	T_7	15	N	N	N
7.	102	96	93	92	92	91	2.9	T_7	25	N	N	N
8.	78	76	69	74	74	76	3.0	T_8	35	N	N	N
9.	96	92	93	96	94	90	2.8	T_6	30	N	N	N
10.	102	100	95	94	90	88	2.8	T_7	40	N	N	N
11.	92	92	94	90	90	90	3.2	T_8	20	N	N	N
12.	88	88	86	78	83	84	2.9	T_9	15	N	N	N
13.	98	99	95	94	92	89	2.8	T_8	35	N	N	N
14.	109	114	107	99	101	100	2.7	T_7	35	N	N	N
15.	115	118	109	104	100	99	2.9	T_8	40	N	N	N
16.	122	126	117	114	110	107	2.7	T_9	20	N	N	N
17.	109	104	104	99	95	96	2.8	T_8	15	N	N	N
18.	78	76	79	73	72	72	3.2	T_8	25	N	N	N
19.	109	102	110	106	101	100	2.7	T_7	45	Y	N	N
20.	84	83	84	82	78	76	3.2	T_7	15	N	N	N
21.	92	96	99	104	90	92	3.2	T_7	30	Y	N	N
22.	88	90	85	85	80	80	3.0	T_9	10	N	N	N
23.	96	95	95	100	104	90	2.9	T_8	45	Y	N	N
24.	103	100	102	96	96	90	2.7	T_9	40	N	N	N
25.	100	99	102	96	96	90	2.7	T_8	20	N	N	N
26.	119	115	116	112	108	103	2.4	T_7	25	N	N	N
27.	99	102	94	92	90	90	2.7	T_8	40	Y	N	N
28.	78	80	82	73	71	70	3.1	T_8	20	N	N	N
29.	84	89	82	83	80	78	3.0	T_8	15	N	N	N
30.	109	110	102	99	97	100	2.7	T_8	15	N	N	N

*- one child demonstrated an episode of Bradycardia, which was treated with intravenous Atropine- 0.02 mg/kg.

GROUP B_2- DATA

Sl. No	Name	Systolic Blood Pressure						Diastolic Blood Pressure					
		bas	5m	10m	15m	30m	60m	Bas	5m	10m	15 m	30 m	60 m
1.	Praveen	110	108	103	104	103	100	70	70	66	67	67	65
2.	Sidharth	110	104	102	103	103	100	70	72	68	65	62	69
3.	Barath	109	104	96	100	102	103	70	68	63	67	64	65
4.	Mahmud	106	105	110	104	104	104	68	70	70	65	64	62
5.	Rajkumr	104	105	103	100	100	100	69	69	66	67	62	63
6.	Prasanna	107	106	102	100	100	102	69	69	66	65	64	65
7.	Ajay	106	102	102	102	100	100	70	64	64	65	66	62
8.	Saifulla	110	108	106	103	100	102	70	69	72	68	66	64
9.	Lavanya	107	102	102	100	100	100	70	68	67	64	62	65
10.	Iswarya	109	106	103	103	103	100	74	70	68	68	65	64
11.	Gayatri	108	104	100	105	106	105	70	68	66	67	68	68
12.	Harsha	105	105	103	100	102	105	69	66	64	65	66	66
13.	Preetha	104	104	102	100	102	102	69	64	60	60	61	63
14.	Raghav	100	101	96	95	98	102	66	62	61	57	60	60
15.	Aruna	104	102	100	101	100	100	69	65	60	60	58	57
16.	Arjun	100	95	94	98	101	100	63	60	58	61	68	66
17.	Saktivel	104	104	100	100	101	100	69	66	62	63	64	60
18.	Nizam	117	112	110	104	106	102	78	71	70	67	70	68
19.	Victor	107	104	102	101	100	101	70	72	69	68	67	68
20.	Akshay	114	109	110	110	105	105	70	68	68	66	67	68
21.	Keziya	112	110	110	105	106	102	70	68	66	62	64	61
22.	Stephen	119	112	108	105	106	104	78	75	78	70	72	70
23.	Anu	120	117	114	110	112	109	78	78	71	74	70	70
24.	Kavitha	110	106	104	105	106	106	71	72	70	74	72	73
25.	Jayanth	105	100	100	101	102	99	68	60	58	61	59	59
26.	Prem	109	104	100	101	100	99	69	61	60	62	61	60
27.	Gautam	104	105	102	102	101	100	68	67	66	62	60	63
28.	Pradeep	118	114	110	111	105	106	76	71	70	72	70	68
29.	Kavya	116	111	109	108	105	104	72	70	70	66	67	69
30.	Madhav	106	101	103	104	102	102	71	67	69	61	59	60

GROUP B_2- DATA

Sl. No	Name	Post-op Complications			2-segment regression	Rescue Analgesic
		PONV	Apn/desat	Headache		
1.	Praveen	N	N	N	45	180
2.	Sidharth	N	N	N	40	140
3.	Barath	N	N	N	50	130
4.	Mahmud	N	N	N	45	110
5.	Rajkumr	N	N	N	45	90
6.	Prasanna	N	N	N	50	165
7.	Ajay	N	N	N	45	135
8.	Saifulla	N	N	N	50	120
9.	Lavanya	N	N	N	40	110
10.	Iswarya	N	N	N	35	85
11.	Gayatri	N	N	N	50	160
12.	Harsha	N	N	N	55	180
13.	Preetha	N	N	N	40	105
14.	Raghav	N	N	N	55	100
15.	Aruna	N	N	N	45	75
16.	Arjun	N	N	N	40	120
17.	Saktivel	N	N	N	50	160
18.	Nizam	N	N	N	55	150
19.	Victor	N	N	N	40	100
20.	Akshay	N	N	N	55	120
21.	Keziya	Y	N	N	40	70
22.	Stephen	N	N	N	45	120
23.	Anu	N	N	N	50	120
24.	Kavitha	N	N	N	40	140
25.	Jayanth	N	N	N	45	135
26.	Prem	N	N	N	40	130
27.	Gautam	N	N	N	40	120
28.	Pradeep	N	N	N	55	150
29.	Kavya	N	N	N	50	155
30.	Madhav	N	N	N	40	130

KEY TO MASTER CHART

PS - American Society of Anaesthesiologists Physical Status

IP.NO.	-	In-patient number
Wt kg	-	Weight in kilos
bas	-	Baseline value
Depth	-	Depth of lumbar puncture
Level	-	Level of sensory blockade
Sx durn	-	Duration of surgery
Suppl	-	Supplementation of anaesthesia
Faild LP	-	Failed lumbar puncture
Faild spinal	-	Failed spinal blockade
PONV	-	Post-operative nausea/vomiting
Apn/desat	-	Apnoea/desaturation
2-segment regression	-	Time to regression by 2 segments
Rescue analgesic	-	Time of analgesic rescue